

MASS LOSS OF FOUR COMMERCIALY AVAILABLE HEAT-POLYMERIZED ACRYLIC RESINS AFTER TOOTHBRUSHING WITH THREE DIFFERENT DENTIFRICES

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ABSTRACT

The association between a toothbrush and a dentifrice is the most used denture cleaning method. The purpose of this study was to evaluate the abrasiveness of specific and non-specific denture cleaning dentifrices on different heat-polymerized acrylic resins. Sixteen specimens (90x30x3mm) of each acrylic resin (QC-20, Lucitone 550, Clássico, Vipi-Cril) were prepared and randomly assigned to 4 groups: 1: control (distilled water), 2: Colgate, 3: Bonyplus and 4: Dentu-Creme. The specimens were subjected to simulated toothbrushing in an automatic brushing machine using 35,600 brush strokes for each specimen. Brushing abrasion run at a 200-g load with the specimens immersed in 2:1 dentifrice/water slurry. Specimens were reconditioned to constant mass and the mass loss (mg) was evaluated. Data were analyzed by 2-way ANOVA and Tukey's test ($\alpha=0.05$). Analysis of dentifrices' abrasive particles was made by scanning electron microscopy. Colgate produced the greatest mass reduction (42.44 mg, $p<0.05$), followed by Dentu-Creme (33.60 mg). Bonyplus was the less abrasive (19.91 mg), similar to the control group (19.69 mg) ($p>0.05$). The mass loss values indicated that QC-20 (33.13 mg) and Lucitone 550 (33.05 mg) resins were less ($p<0.05$) resistant to abrasion than Clássico (26.04 mg) and Vipi-Cril (23.43 mg). In conclusion, Colgate produced the greatest abrasion. Specific dentifrices for dentures tend to cause less damage to acrylic resins.

Key words: Acrylic resins. Brushing. Dentifrice. Abrasion.

INTRODUCTION

Biofilm accumulation on the surfaces of dentures is a common problem among denture wearers^{9,18,24}. Some studies have shown that colonization of denture inner surfaces by yeasts causes oral and systemic diseases^{11,23}, particularly in aged and immunodepressed patients and those with reduced salivary flow^{11,26}. It has been demonstrated association between biofilm and denture-induced stomatitis^{1-3,5,6}. Thus, correct denture cleansing is essential in preventing oral diseases among edentulous patients.

The mechanical removal of debris with the use of toothbrush, dentifrice and water is a popular cleansing technique used by great part of denture wearers⁷. Although it is a simple, inexpensive and effective method^{10,25}, a major disadvantage is that the abrasive action could result in wear

of the denture base and relining materials^{10,12}.

Abrasion caused by brushing of acrylic resin denture bases polymerized by different methods may result in mass loss, surface roughness, loss of surface polishing, problems on denture adaptation due the loss of surface details and difficulty on the maintenance of denture hygiene^{7,21,22,27}. Irregularities on acrylic resin surface favor biofilm formation and pigmentation^{16,20,28,29}. The critical threshold surface roughness for bacterial adhesion is $0.2 \mu\text{m}^{30}$ and the acceptable mass loss of acrylic resins is still unknown.

Dentifrices usually have a complex composition, varying among different brands. The main components are: water, detergent, thickening agent and specific coloring, flavoring and abrasive agents^{13,15}. The most commonly used abrasives in dentifrices are silica and calcium carbonate. Most *in vitro* studies employ motor-driven brushing machines, in order

to standardize time, speed, frequency of brush strokes, applied load and amount of dentifrice^{19,28}. The methods used for measurement of abrasion include mass loss, luster changes, surface roughness, microscopic examination and radiometric technique.

Investigating the abrasion resistance of different denture resins together with the abrasiveness of different dentifrices is of clinical interest to help selecting the most appropriate materials and methods for denture cleansing with no significant damage to the denture base. The aim of this study was to evaluate the mass loss of four commercially available heat-polymerized acrylic resins after simulated toothbrushing with three different dentifrices. The tested null hypothesis was that different denture resins and dentifrices produce different mass loss after toothbrushing.

MATERIALS AND METHODS

The acrylic resins and dentifrices used in this study are presented in Tables 1 and 2, respectively. These products were selected as being representative of those available on the market.

Sixteen specimens of each acrylic resin were fabricated using a stone mold. Plexiglas patterns (90x30x3mm) were included into investment flasks (No. 6 Jon, Jon, São Paulo, SP, Brazil) to allow reproduction of specimens by conventional dental procedures. The acrylic resins were mixed following the manufacturer's instructions and inserted into

the mold. After polymerization, the specimens were bench cooled at room temperature before being removed from the mold and were thereafter carefully finished, polished and immersed in water at 37°C for 7 days until use¹⁷. The specimens were designed to fit on the custom-made metal plate of the brushing machine.

The specimens of all acrylic resins were allocated to 4 groups (n=4). In group 1, (control), the specimens were brushed with distilled water; in group 2, the specimens were brushed with a dentifrice indicated for natural teeth (Colgate); in groups 3 and 4, the specimens were brushed with dentifrices specific for complete dentures (Bonyplus and Dentu-Creme, respectively).

Prior to simulated toothbrushing, the specimens were removed from the water bath, rinsed with tap water, cleaned for 1 min in an ultrasonic bath with deionized water containing 1% of detergent (Limpol neutral, Bombril S/A, São Bernardo do Campo, Brazil), dried with absorbent paper and weighed in an analytical balance accurate to 0.1 mg after 1 min (Mettler Toledo GmbH, Laboratory & Weighing Technologies, Greifensee, Switzerland).

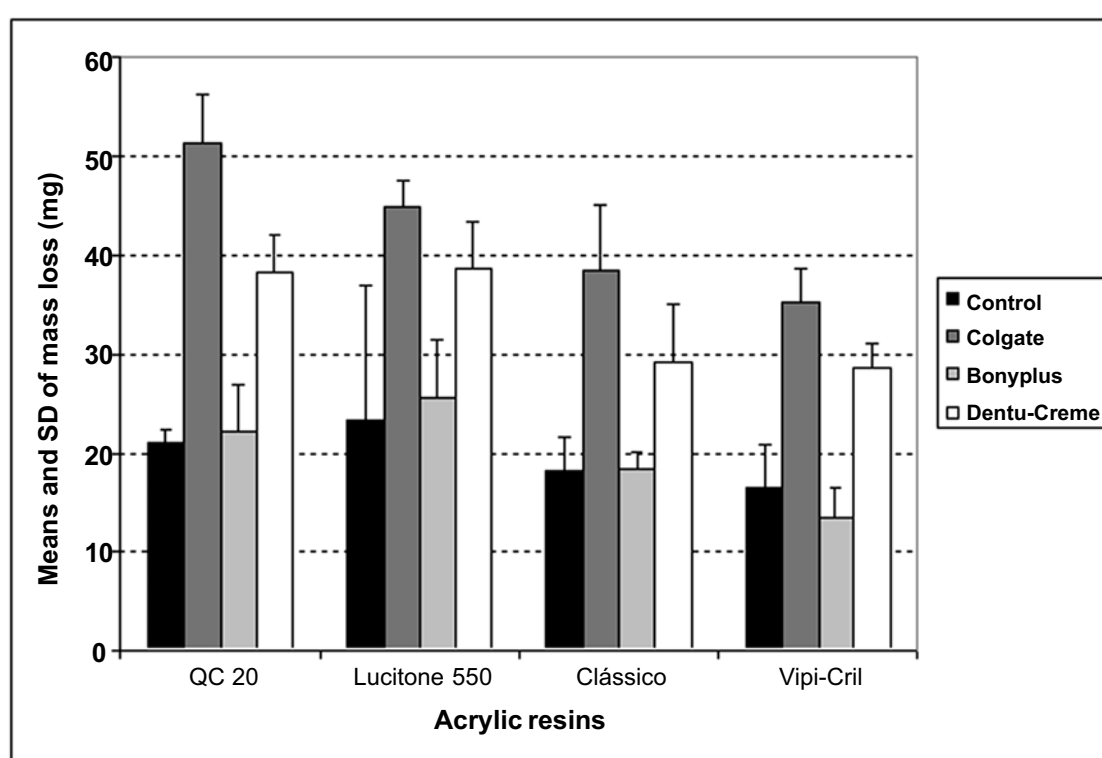
The specimens were positioned in the specimen holder containing the slurry bath in the mechanical cross-brushing machine (Precision Shop, University of São Paulo, Ribeirão Preto, São Paulo, Brazil) equipped with 6 soft nylon-bristled toothbrushes (Tek, Soft, Johnson & Johnson), in such a way that 6 specimens could be brushed simultaneously. The specimens were subjected to a linear toothbrush abrasion movement with a rate of 356 brush strokes (forth and back)

TABLE 1- Specifications of the tested heat-polymerized acrylic resins

Commercial Brand	Manufacturer/City/Country	Composition
Lucitone 550	Dentsply Ind. Com. Ltd Petrópolis, RJ, Brazil	Polymer powder: copolymer (methyl-n-butyl) methacrylate, benzoyl peroxide. Monomer Liquid: methyl methacrylate, ethylene glycol dimethacrylate, hydroquinone.
QC-20	Dentsply Ind. Com. Ltd Petrópolis, RJ, Brazil	Polymer powder: copolymer (methyl-n-butyl) methacrylate, benzoyl peroxide. Monomer Liquid: methyl methacrylate, ethylene glycol dimethacrylate, hydroquinone, terpinolene, N-dimethyl-p-toluidine.
Clássico	Artigos Odontológicos Clássico Ltd São Paulo, SP, Brazil	Polymer powder: copolymer (methyl-n-butyl) methacrylate, benzoyl peroxide. Monomer Liquid: methyl methacrylate, ethylene glycol dimethacrylate, hydroquinone.
Vipi Cril	Dental Vipi Ltd Pirassununga, SP, Brazil	Polymer powder: copolymer (methyl-n-butyl) methacrylate, benzoyl peroxide. Monomer Liquid: methyl methacrylate, ethylene glycol dimethacrylate, hydroquinone.

TABLE 2- Characteristics of tested dentifrices

Dentifrice	Manufacturer	Abrasive particles	Indication
Colgate com cálcio	Colgate-Palmolive, Divisão da Kolynos do Brasil, Osasco, SP, Brazil	Calcium carbonate	Natural teeth
Bonyplus	Bonyf AG, Vaduz, Liechtenstein	None	Complete dentures
Dentu-creme	Block Drug Company Inc., Jersey City, NJ, USA	Calcium carbonate	Complete dentures

**FIGURE 1-** Means and SD of mass loss (mg) of the tested acrylic resin after dentifrice use

per minute, totalizing 35,600 brush strokes for each specimen, which is representative of 2 years of denture cleansing¹³. The machine was set to provide 200 g vertical load over each specimen and a 3.8 cm toothbrush trail. Brushing was carried out in the presence of a dentifrice/distilled water slurry (2:1; w/w), which was placed into the slurry bath¹⁷. A stainless steel agitating fin was fastened to the end of the brush to ensure adequate mixing, so that settling of the abrasive material would be minimized during brushing.

After brushing, the specimens were removed from the specimen holder, rinsed thoroughly and blot dried with soft absorbent paper. Each specimen was weighed in the analytical balance as previously described. Mass loss due to wear was calculated as the difference between the mass of each specimen before and after brushing.

The results of mass loss were subjected to 2-way ANOVA

and Tukey's test ($\alpha=0.05$) to examine the influence of materials and groups.

RESULTS

Figure 1 shows the means and standard deviation (SD) of the mass loss (mg) of the tested acrylic resins after toothbrushing.

The results of ANOVA are presented on Table 3. According to the Tukey's test for mass loss (mg) of acrylic resins and dentifrices, the resins QC-20 and Lucitone 550 showed greater mass reduction, which indicated lower abrasion resistance as compared to the other resins. Colgate was the most abrasive dentifrice, followed by Dentu-Creme and Bonyplus (Tables 4 and 5).

TABLE 3- ANOVA results for mass loss of acrylic resins

	df	SS	V	F	
D	5935.9453	3	1978.6484	69.85	♦
R	1171.8828	3	390.6276	13.79	♦
DxR	231.0508	9	25.6723	0.91	ns
Residuals	1359.7305	48	28.3277		
Total variation	8698.6094	63			

D: dentifrices; R: acrylic resins; ♦: $P < 0.05$; ns: non-significant.

TABLE 4- Means of mass loss promoted by each dentifrice on the acrylic resins evaluated in this study

Colgate	Dentu-Creme	Bonyplus	Control
42.438 ^a	33.600 ^b	19.906 ^c	19.694 ^c

Different letters indicate statistically significant difference ($p < 0.05$).

TABLE 5- Means of mass loss of each acrylic resin promoted by the dentifrices used in this study

QC-20	Lucitone 550	Clássico	Vipi-Cril
33.125 ^a	33.050 ^a	26.037 ^b	23.425 ^b

Different letters indicate statistically significant difference ($p < 0.05$).

DISCUSSION

Since dentifrice and toothbrush association is one of the most common methods for oral hygiene, it should promote good cleansing with minimal damage to teeth, gingival tissues and restorative and prosthetic materials. It is thus important to evaluate the abrasion resistance to brushing of heat-polymerized acrylic resins used for fabrication of denture bases. The acrylic resin hardness, the type of abrasive agent and its concentration, the dimension and form of abrasive particles, the toothbrush and the load applied are some of the different factors that influence the abrasion of acrylic resin by brushing^{4,7,12}.

Colgate and Dentu-Creme dentifrices use calcium carbonate as abrasive particles. In the present study, the results showed that Colgate was significantly more abrasive than Dentu-Creme (Table 4), as reported by Freitas and Paranhos (2006)¹⁰. This previous study¹⁰ also showed, by microscopic analysis, that Colgate's abrasive particles presented an irregular spherical form, irregular size and heterogeneous distribution, while Dentu-Creme's abrasive particles presented a regular form, small size and homogeneous distribution. This confirms the importance of the abrasive agent's particles form, size and distribution on the abrasive capacity of dentifrices^{4,12}.

Some abrasion is necessary for stain removal. The present study did not analyze this topic. Many variables must be considered in the fabrication of dentifrice for cleansing and polishing: acrylic porosity, hardness, size and surface configuration of the cleansing agent, the type of compounds for polishing used along with the cleansing agent, and the hardness of the cleansing and polishing agent²⁰.

Some studies have demonstrated the importance of

dentifrice abrasiveness on promoting an efficient cleansing because brushing with water alone does not remove stains and organic deposits from dentures^{13,14}. Furthermore, low-abrasion dentifrices do not remove stains from smoker's dentures either²². Therefore, abrasion is an important issue to be considered when selecting a dentifrice. It should be abrasive enough to maintain the denture clean¹⁵.

A soft-bristle toothbrush was used in the present study because it is cheap and has good quality, being therefore accessible to most patients. Brushing with distilled water caused minimum mass reduction, confirming the results from other studies²⁸. Bonyplus has no abrasive particles and its results were statistically similar to the control group.

The purpose of this study was to compare dentifrices under the same experimental conditions. Each specimen was subjected to 35,600 brush strokes, and the load applied on each brush head was 200 g, which was estimated to be equivalent to 2 years of manual brushing²⁸. Correlation between *in vitro* tests and clinical reality is difficult. Artificial brushing is vigorous and may be more abrasive than manual brushing¹⁹, but some works have shown similar results between laboratory and clinical experiments^{20,21}. Resin characteristics, such as monomer/polymer ratio, presence of cross-linking agents, mixture uniformity, polymerization cycle, cooling rate, specimen thickness and surface finishing may influence the interaction between specimens and dentifrices. It is therefore necessary to standardize these variables as carefully as possible¹³.

There is some divergence regarding the use of gravimetric method for abrasion measurement. Mass reduction is approved by the ISO/TC 106 (1996)¹⁷ specification as an abrasion indicator and it is the simplest method of producing values for abrasion of acrylic resins²⁵.

Due to the experimental conditions of this study, mass reduction was analyzed to assess abrasion. Sexson and Phillips²⁷ showed that mass reduction obtained from brushing rotating acrylic resin specimens was similar to that produced when specimens were allowed to remain stationary, although microscopic examination revealed that the rotating specimens had different surface topography. Hence, surface roughness and brightness loss would not provide results valid for this study, in which the specimens remained stationary.

During the brushing procedure, the specimens were kept immersed in dentifrice slurry for 100 min and some water sorption could occur. For this reason, the specimens were stored in water at 37°C for 7 days before the test in order to balance water sorption¹⁷.

When submitted to cycles at higher temperature, heat-polymerized acrylic resins have been shown to produce specimens with higher abrasion resistance^{25,28}. Haselden, et al.¹² verified that the effects of Colgate and Dentu-Creme dentifrices differed according to the resins used and ranking order was unpredictable. In this study, Colgate was more abrasive than Dentu-Creme for all specimens. Hence, the ranking order was the same for all acrylic resin brands. QC-20 and Lucitone 550 resins showed greater mass reduction as compared to the other resins when submitted to brushing associated to dentifrice (Table 5). These were unexpected results because all the resin groups had similar polymerization cycles.

An important question concerns the clinical relevance of the abrasion produced by dentifrices on dentures. Facq and Volpe⁸ concluded that the abrasion of dentifrices on veneer crowns was clinically insignificant. Murray, et al.²² stated that it is possible to estimate that twice daily brushing for 2 min with a dentifrice containing calcium carbonate would result in the removal of 25 μm of resin surface *per* year. Therefore, further studies similar to the present one are required to determine the impact of the wear produced by dentifrices on dentures. *In vitro* experiments are usually helpful to compare the relative effectiveness of denture cleansers and to develop an understanding of the acting mode of each denture cleanser²³. In addition, the present study provides more details concerning the performance of some acrylic resins under abrasive load. It might help dentists indicating cleansers for denture wearers.

CONCLUSION

Based on the obtained results and within the limitations of an *in vitro* study, it may be concluded that differences exist among heat-polymerized acrylic resins concerning abrasion resistance and that dentifrices specific for denture cleansing tend to cause less damage to acrylic resin surface.

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